

"Lake Erie Total Phosphorus Loads, 1996-2000"

Quality Assurance Project Plan

**Submitted to
U.S. EPA Great Lakes National Program Office
and
U.S. EPA Region V
Chicago, IL**

By

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A1. Approvals

David M. Dolan, Principal Investigator & Project Manager, UWGB	Date
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David Rockwell, Project Manager, USEPA GLNPO	Date
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Louis Blume, Quality Assurance Manager, USEPA GLNPO	Date
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A3. Distribution List

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A4. Project / Task Organization

Dr. Dolan is the Principal Investigator of this project, and as such has the responsibility to oversee all aspects of this project. The PI will review all load estimates made by his personnel, and review the performance of data management by his personnel; he will direct and evaluate any necessary corrective action. He has the overall responsibility to ensure the quality of all loads estimated by this project.

Dr. Dolan reports to the EPA Great Lakes National Program Office (GLNPO) Project Officer, David Rockwell or his designate. The QAPP is reviewed and approved by the EPA GLNPO Quality Assurance Officer, Louis Blume.

Dr. Dolan will provide interpretation of the data generated by this project in coordination and cooperation with appropriate staff from EPA GLNPO.

A5. Problem Definition / Background

One of the best developed indicators of progress in achieving Great Lakes water quality goals is the mean annual loading of total phosphorus to each lake. For the past 25 years, particular emphasis has been placed on total phosphorus because the International Reference Group on Great Lakes Pollution from Land Use Activities (PLUARG) recommended target loads for each of the lakes based on detailed analysis of their eutrophication status. Tributary monitoring programs and associated point source and atmospheric deposition monitoring allowed progress in meeting these targets to be reported throughout the 1980s and into the 1990s. Key components of the total loading such as municipal and non-point sources were tracked as remedial control measures were put in place. Improvements in computer availability and networking allowed greater accessibility and quicker reporting of results. Unfortunately, budget cuts to environmental programs in the mid 1990s had a dramatic effect on monitoring efforts, particularly on tributary sampling. No total phosphorus load estimates are available for any lake after 1995.

The Lake Erie Millennium Plan (LEMP) is a binational effort of research organizations, including the U.S. EPA, “to foster and coordinate research that will identify and solve basic ecological questions relevant to the Lake Erie Ecosystem through a binational, collaborative network.” At a recent LEMP event (The Lake Erie in the Millennium Conference, March 28-29, 2001, at the University of Windsor), U.S. and Canadian researchers presented the latest information on the ecosystem components and process that were changing most rapidly and/or were of the greatest concern. Without exception, investigators reporting on water quality, plankton communities, fish stocks and the food webs that link these components noted that their efforts have been hampered by a lack of knowledge of nutrient loads to Lake Erie. Further, the key nutrient that drives many aspects of the ecosystem is still phosphorus.

A6. Project / Task Description

The overall objective of this project is to revive phosphorus load estimation efforts for the Great Lakes, using Lake Erie (1996-2000) as an example. Point source and atmospheric deposition monitoring results are available to allow continued estimation of these components. Several key watersheds are still being monitored, making some tributary load estimation possible. Additional tributary data are available from the U.S.G.S. study conducted from 1996-1998.

Specific tasks include: 1. Assess status of phosphorus data needed for Lake Erie load estimation. 2. Collate data from U.S. and Canada into common formats required for computation. 3. Make estimates for each component (tributary, point source and atmospheric) of total lake loading including unmonitored areas. 4. Prepare tables and graphs of results showing subtotals for lake basin (Western, Central and Eastern) and source (point, nonpoint, etc.). 5. Assess feasibility of extending approach to the other four lakes. 6. Recommend improvements to streamline load estimation process. 7. Train environmental science students to understand and conduct load estimation studies.

A7. Quality Objectives and Criteria for Measurement Data

No new environmental measurement data will be obtained during this project. However, data are to be acquired from government agencies as indicated in B9 below. The assumption that the quality objectives and criteria for the purpose of these agencies will be adequate for purposes of this project is critical to the completion of this study. Numerous studies have been conducted in the past to ensure that this was indeed the case. Further studies of this nature are beyond the scope of this project.

In the opinion of the PI, the flow and total phosphorus data currently being generated by the agencies in B9 below are of comparable quality to data reported by these agencies previously with one notable exception. Some tributary total phosphorus concentrations are being reported as “less than the detection limit” or censored. When data are reported in this way, it is not possible to estimate phosphorus loads directly. This problem is being dealt with in one of two ways depending on the availability of additional data.

If additional data are available on the same sampling date that are not censored (from other agencies at the same location or duplicate sampling), the censored value is discarded.

If additional data are not available, a replacement value is imputed to the data set using the following procedure:

1. Loads for all sampling dates for a given tributary and year are calculated by taking the product of flow and total phosphorus concentration or the detection limit (whichever has been reported).
2. These loads are log-transformed to ensure admissible estimates.

3. Replacement loads for all censored sampling dates are estimated by the MLE procedure developed by El-Shaarawi and Dolan (1989).
4. Replacement total phosphorus concentrations are calculated by dividing the replacement load by the flow for that date.
5. Replacement values are substituted into the data set for purposes of stratified ratio estimation. These values are flagged for identification purposes.

A8. Special Training / Certification

The personnel at the University of Wisconsin – Green Bay involved in completing the technical aspects of this project have strong backgrounds in environmental science. Further, while they are not computer programmers, they are familiar with databases, spreadsheets, statistical packages and computer files. They also have training in statistics beyond the introductory level.

The PI has twenty years of experience in conducting this kind of load estimation project.

A9. Documentation and Records

Project documentation will include notebooks, raw data files, final processed data (in spreadsheet files), and summary tables. This information is available for review on site by the EPA Project Officer or QA Officer.

SECTION B. DATA GENERATION AND ACQUISITION

B1. Sampling Process Design

N/A.

B2. Sampling Methods

N/A.

B3. Sample Handling and Custody

N/A.

B4. Analytical Methods

N/A.

B5. Quality Control Requirements

N/A.

B6. Instrument / Equipment Testing, Inspection and Maintenance

N/A.

B7. Instrument / Equipment Calibration and Frequency

N/A.

B8. Inspection/Acceptance of Supplies and Consumables

N/A.

B9. Data Acquisition Requirements

All of the data used to estimate Lake Erie Total Phosphorus Loads come from government databases. The following is a list of the required data, database name (if any) and the responsible agency.

U.S. Point Source dischargers in Lake Erie Basin (Monthly Average Effluent Flow and Total Phosphorus Concentration). Database: Permit Compliance System (PCS). Responsible agencies: U.S. EPA and States: New York, Pennsylvania, Ohio, Indiana and Michigan.

Canadian Point Source dischargers in Lake Erie Basin (Monthly Average Effluent Flow and Total Phosphorus Concentration). Database: Municipal and Industrial Strategy for Abatement (MISA) database. Responsible Agency: Ontario Ministry of the Environment.

U.S. Daily Average Tributary Flows for gauged Lake Erie tributaries. Database: WATSTORE. Responsible Agency: U.S.G.S. Water Division.

Canadian Daily Average Tributary Flows for gauged Lake Erie tributaries. Database: Available on CD-ROM. Responsible Agency: Environment Canada, Water Survey Canada.

U.S. Tributary Total Phosphorus Concentrations for monitored Lake Erie tributaries. Database: STORET. Responsible Agencies: U.S. EPA, U.S.G.S., New York DEC, Ohio EPA, Michigan DEQ.

Canadian Tributary Total Phosphorus Concentrations for monitored Lake Erie tributaries. Database: Stream Monitoring System. Responsible Agencies: Ontario Ministry of the Environment.

Total Phosphorus Concentrations in Rainfall and Rainfall Amounts in the Lake Erie Basin. Database: Available in spreadsheet format. Responsible Agency: Environment Canada.

B10. Data Management and Load Estimation Methods

Once the data has been acquired from the sources identified in B9, its receipt will be documented and it will be maintained as an archive. Copies will be made of the original data (in “flat” or text-file format) for use with existing SAS and FORTRAN programs on the EPA-NCC mainframe computer. This software is known to perform reliably.

These programs are used to prepare the data for the load estimation process, estimate the load from individual and area sources, and summarize the resulting loads by type and geographic sub-units. The methods used to estimate loads vary by type of source, but the basic calculation involved is forming the product of concentration multiplied by volume per unit time to produce the mass per unit time. This quantity is then averaged over the required time period. For example, to estimate loads from point sources, the following calculations (Dolan, 1993) can be used to report annual average point source phosphorus loads:

$$\text{Loading} = (\sum C_i Q_i) / n \quad \text{for } i = 1, 2, \dots, 12$$

where C_i is the average total phosphorus effluent concentration for the i th month

Q_i is the mean effluent flow for the i th month

and n is the number of months of monitoring.

These calculations are performed on a “per pipe” basis and the estimates are summed (for multi-pipe facilities) to provide loads on a “per facility” basis.

For monitored tributaries, the Stratified Beale’s Ratio Estimator (Beale, 1962; Tin, 1965; Dolan *et al.*, 1981) is used. Daily tributary loads are calculated on a yearly basis for each tributary and then the data are stratified into one or more strata depending on the nature of the flow and concentration relationship within each strata. In general, tributaries with greater than monthly sampling frequency are stratified into at least two strata.

For unmonitored tributaries, a unit area load (UAL) is estimated from nearby monitored tributaries and applied to the unmonitored basin area. For details of this procedure, see Rathke and McCrae (1989).

For atmospheric loadings, the flux of phosphorus in units of mass per area is estimated from precipitation collectors and applied to the lake area that the collector represents. This is also detailed in Rathke and McCrae (1989).

SECTION C. ASSESSMENT AND OVERSIGHT

C1. Assessment and Response Actions

Dr. Dolan will monitor all project-related activities.

The results of this project may be published, and if so will undergo anonymous outside peer review by experts in the field.

C2. Reports to Management

Due to the short duration of this project, the PI will provide one progress report to the EPA Project Officer in December, 2001 which will summarize all progress to date. A Final Project Report will be provided to the EPA Project Officer at the end of the project that includes all project results.

SECTION D. DATA VALIDATION AND USABILITY

D1. Data Review, Verification and Validation

The responsibility for basic data review, validation and verification lies with the agency that collected the data. However, additional data screening for the purpose of load estimation will be conducted. A series of SAS programs are used to identify outliers by checking for internal consistency and comparing to historical information. In general, data points that depart from the current and/or historical average by more than two standard deviations are investigated.

D2. Verification and Validation Methods

Data points that are flagged as potential outliers are investigated for assignable cause. Adjustments can be made for causes such as a change in units or analytical method. When the cause is failure of instrumentation or a missing sample, data points are deleted and, if necessary, replacement values are imputed using accepted procedures. See A7 above.

D3. Reconciliation with User Requirements

The information required by the user is the estimate of total phosphorus load for Lake Erie for the years 1996-2000. The main requirement is that the information should be

obtained in the same way as previous load estimates to ensure comparability. A statement will be provided that documents how standard methods for load estimation were used and noting any deviations.

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- Dolan, D.M., Yui, A.K., and Geist, R.D. 1981. Evaluation of river load estimation methods for total phosphorus. *J. Great Lakes Res.* 7(3): 207-214.
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